SCHOOL OF CHEMICAL SCIENCES

Swami Ramanand Teerth Marathwada University, Nanded-431606

(CBCS PATTERN)

Program: M. Sc. (Chemistry)

(With specialization in Analytical, Industrial, Medicinal, Organic, Physical and Polymer)

Academic Center

SCHOOL OF CHEMICAL SCIENCES(CAMPUS)

School Code- SCH-11. Program Code -1, Faculty Code-S, Numeric Code- 11-2-1-01, Alphabetic Code -SCH-S-CHE-PG

Objectives

- To encourage students to develops curiosity and a spirit of enterprise.
- To teach students to be aware of the safety of oneself and others in laboratory and be committed to safe practices in daily life.
- To teach good laboratory practice and skills.
- To teach students to analyze data from experiments or from other sources.
- To acquire students a readiness in becoming responsible citizens in changing world.
- To provide students with some insight into future career prospect in the fields related to Chemistry.

Program Specific Outcomes

- To impart the chemistry knowledge of global standard
- Global level opportunity for research and Ph.D. program
- Discipline specific competitive examinations conducted by different organizations
- Enormous job opportunities in chemical, pharmaceutical, food and material industries including academic institutions
- Specific placement in R and D in various industries
- To develop Entrepreneur ship
- To understand Environmental risk and remedies
- Develop approach towards sustainable development
- Impart skill to work in chemical research organizations / industries

Program Outcomes

- Theory and Knowledge: Students will have knowledge of the fundamental principle and contemporary practices of chemistry and will be able to use them to investigate, explain and predict new phenomena.
- Laboratory Skills: After completion of a M.Sc. degree, Chemistry majors are able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments at a level suitable to succeed at an entry- level position in research, academia, or chemical industry.
- Quantitative skills: Chemistry majors are able to interpret and analyze quantitative data.
- Think scientifically: Students acquire an ability to think scientifically, independently and to make rational discussion.
- Promote awareness: To promote an awareness of social, economic, environmental and technological implication of chemistry.
- Job opportunities : Job opportunities in Chemical industries, pharmaceutical, foods and materials ,Research and Development in various institutions including academic institutions

Revised in academic year 2018-19 and to be implemented from academic year 2019-20

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   5) Physical Chemistry [PHCH]
   6) Polymer Chemistry[POCH]

SCHOOL OF CHEMICAL SCIENCES

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WITHEFFECTFROMACADEMICYEAR 2019-2020

FEATURES OF THE CREDIT SYSTEM

1. Master's degree would be of 100 creditseach.
2. The 2 credit course of theory will be of 2 clock hours per week running for 12 weeks.
3. The 4 credit course of theory will be of 4 clock hours per week running for 12 weeks
4. The 4 credit course of practical's will consist of 8 hour of laboratory exercise for 12 weeks
5. The 8 credit course of research project/industrial training will consist of (a) 16 hour of laboratory exercise for 12 weeks or (b) 196 hours of work
6. One credit course of seminar will be of 15 clock hour running for 12 weeks.

Note: Open electives (for 8 credits) may preferably be chosen during semester I, II. III. As a result students can opt more credits per semester than specified as following

Semester I and II shall have 5 Theory courses, 2 Practical courses and 1 Seminar.

Three Theory Core Courses	x4credits	=	12credits
Two Theory Core Courses	x2credits	=	04credits
TwoPracticalcourses	x 4credits	=	08credits
One Seminar	x1credit	=	01credit
Total		=	25credits

Semester III shall have 4 Theory courses, 2 Practical courses and 1 Seminar.

Two Theory Core Courses	x4credits	=	08credits
One Theory Elective (Intra) Course	x4credits	=	04credits
One Theory Elective (Inter) Course	x4credits	=	04credits
Two Practicalcourses	x 4credits	=	08credits
One Literature survey and Seminar	x 2credit	=	02credit
Total	l	=	26credits

Semester IV shall have 4 Theory courses, 1 Research project/Industrial training and 1 Seminar.

Two Theory Core Courses	x4credits	=	08credits
One Theory Elective (Intra) Course	x4credits	=	04credits
One Theory Elective (Inter) Course	x4credits	=	04credits
One Research project/Industrial training	x 8credits	=	08credits
Total		=	24credits

Each credit carries 25 marks
The assessment will be as follows

- **FOUR CREDITS (THEORY/PRACTICAL) = 100Marks**

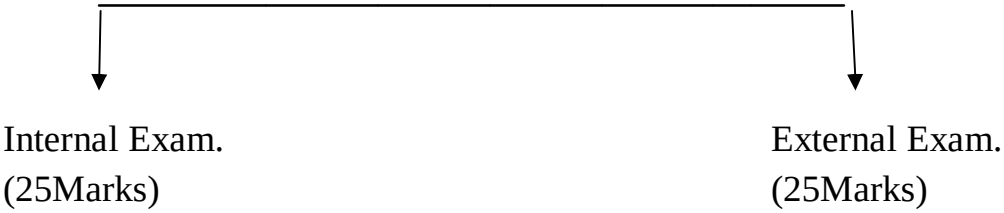
- Break up of **Internal Theory Exam.** (50 marks) is asfollows:

Test -1	Test-2	Home Assignment	Total
20	20	10	50

- Break up of **internal/external Practical exam.(50 marks)** is asfollows,

Question 1	Question 2	Viva-voce	Record book	Total
20	20	5	5	50

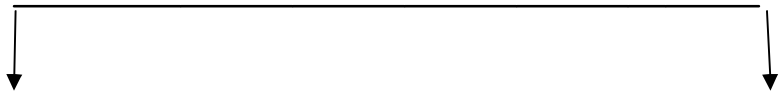
- 2 Credits (THEORY) = 50MARKS



- Break up of **Internal Theory Exam.** (50 marks) is asfollows:

Test -1	Test-2	Home Assignment	Total
20	-	05	25

- 8 Credits (Research project/Industrial training) = 200MARKS



Internal Exam. (100Marks)

External Exam. (100Marks)

- Break up of **Internal Theory Exam.** (100 marks) is asfollows:

Literature Survey	Defining research problem	Plan for executing the work	Presentation of progress	Total
20	20	20	40	100

- Academic calendar showing dates of commencement and end of teaching, internal assessment test and term end examination shall be duly notified before commencement of each academic year.
- Credits system offers more options to the student.
- Credits system offer more flexibility to the student.
- Student can get requisite credits from the concerned school where he is mutually permitted on terms mutually agreed to complete the same and be eligible to appear for term end examination.
- The term end examinations however, shall be conducted by & at the school.
- Paper setting and assessment for a particular course would be the responsibility of the course in-charge.
- These activities related to the examination would be coordinated by the School Examination committee comprising course In-charges and HOD under supervision of the(Director).

- Marks obtained for each course would be converted to grade points as shown in table1

Table 1: Conversion of marks to grades in credits system

Marks obtained	Grade	Grade points
100-90	A+	10
89-80	A	09
79-70	B+	08
69-60	B	07
59-55	C+	06
54-45	C	05
44-40	D	04
39 and less	FC	0-FAIL BUT CONTINUE
39 and less internal	FR	0- FAILED (CLEAR COURSE)

- A student who passes the internal tests but failed in semester Examination (External) of course shall be given FCgrade.
- Student with FC grade in a course would be granted credits for that course but not the grade for that course. He/she shall have to clear the concerned course within 1.5 year from appearing for the first time in concerned paper, provided the number of courses with FC and FR grades together is 25% or less of the courses of that semester.
- Failing which he/she shall be disqualified for credits and will have to opt for other credits.
- Student who has failed in the internal tests of a course shall be given FR grade and shall have to (clear) the concerned course.
- Grade points earned in each paper shall be calculated as grade points obtained (vide table 1 above) X credits for the paper.

- The Student Performance Index (SPI) gives weighted performance index of a semester with reference to the credits of a course.

The SPI shall be calculated as follows:

$$SPI=\frac{\text{Total earned grade points for thesemester}}{\text{Total credits for the semester}}$$

- Final results: For the final results of a student Cumulative Performance Index (CPI) based on total earned credits vis a vis total earned grade points shall be calculated.

The CPI shall be calculated as follows,

$$CPI=\frac{\text{Total earned grade points}}{\text{total credits i.e.100}}$$

- Student will have to complete 75 compulsory credits for the concerned course, 15 elective credits in the subject concerned and 10 optional credits incorporated in the syllabus structure of respective master (PG)course.

- Some of the elective credits and optional credits shall be chosen from elective and optional courses offered by the school of Chemical Sciences or other campus schools of the University.

- The school in consultation with the Dean, Faculty of Science can make changes in syllabi.

CPI		FINAL GRADE
9.0	- 10	A+
8.0	- 8.9	A
7.0	- 7.9	B+
6.0	- 6.9	B
5.5	- 5.9	C+
4.5	- 5.4	C
4.0	- 4.4	D
0.0	- 3.9	F

- Final mark list will only show the grade and grade points and not the marks.

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School of Chemical Sciences
Swami Ramanand Teerth Marathwada University

CHEMISTRY CURRICULUM
M. Sc. Chemistry Core and Elective papers

M. Sc. F. Y. (First Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Core papers				
1.	CH-101	Physical Chemistry	60	4
2.	CH-102	Inorganic Chemistry	60	4
3.	CH-103	Organic Chemistry	60	4
4.	CH-104	Basic Principals of Spectroscopy	30	2
5.	CH-105	Symmetry and Group Theory	30	2
Practical courses				
6.	LCH-101	Physical Chemistry (Laboratory course 1)	120	4
7.	LCH-102	Inorganic Chemistry (Laboratory Course 2)	120	4
8.	SCH-101	Seminar	15	1
***Open elective (Students from other schools)**				
1.	OE_SES_01 (OCH-101)	Lab Safety	30	2

*** This course is available for students from school of chemical sciences as add-on-course**

M. Sc. F. Y. (Second Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Core papers				
1.	CH-201	Physical Chemistry	60	4
2.	CH-202	Inorganic Chemistry	60	4
3.	CH-203	Organic Chemistry	60	4
4.	CH-204	Inorganic Spectroscopy	30	2
5.	CH-205	Quantum chemistry & Spectroscopy	30	2
Practical courses				
6.	LCH-201	Organic Chemistry (Laboratory course 1)	120	4
7.	LCH-202	Analytical Chemistry (Laboratory Course 2)	120	4
8.	SCH-201	Seminar	15	1

M.Sc.S.Y.Core and Elective papers
(SPECIALIZATIONS)

M. Sc. S. Y. Analytical Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Analytical Chemistry Core papers				
1.	ACH-311	Principles of Analytical Chemistry	60	4
2.	ACH-312	Chromatographic Methods of Analysis	60	4
		Practical Courses		
1.	LACH-311	Laboratory Course 1	120	4
2.	LACH-312	Laboratory Course 2	120	4
1.	SACH-311	Seminar	15	1

M. Sc. S. Y. Analytical Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Analytical Chemistry Elective papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EACH-311	Organic Spectroscopy	60	4
2.	EACH-312	Spectrochemical methods of Analysis	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 (OPCH-311)	Intellectual property rights	60	4

M. Sc. S. Y. Analytical Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Analytical Core papers				
1.	ACH-411	Electro-analytical and thermal methods of analysis Chemistry	60	4
2.	ACH-412	Applied Analytical Chemistry	60	4
Practical Courses				
1	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8
2	SACH-411	Seminar	15	1

M. Sc. S. Y. Analytical Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Analytical Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EACH-411	Quality Assurance and Quality control, method of Analytical Development and Validation	60	4
2.	EACH-412	Techniques for forensic Analysis	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4

Open electives offered for students from other schools				
1.	OE_SES_03 (OPCH-411)	Industrial safety and hazardous management	60	4

M. Sc. S. Y. Industrial Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Industrial Chemistry Core papers				
1.	ICH-321	Unit Operations	60	4
2.	ICH-322	Unit processes in Organic Synthesis	60	4
Practical Courses				
1.	LICH-321	Laboratory Course 1	120	4
2.	LICH-322	Laboratory Course 2	120	4
1.	SICH-321	Literature survey and Seminar	30	2

M. Sc. S. Y. Industrial Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Industrial Chemistry Elective papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EICH-321	Organic Spectroscopy	60	4
2.	EICH-322	Industrial pollution and Control	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 OPCH-311	Intellectual property rights	60	4

M. Sc. S. Y. Industrial Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Industrial Chemistry Core papers				
1.	ICH-421	Transportation Processes in Unit Operations	60	4
2.	ICH-422	Process Industry and Industrial Pollution Management	60	4
Practical Courses				
1	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8

M. Sc. S. Y. Industrial Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Industrial Chemistry Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EICH-421	Agrochemicals and Pesticides	60	4
2.	EICH-422	Synthetic methods in organic chemistry	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_03 (OPCH-411)	Industrial safety and hazardous management	60	4

M. Sc. S. Y. Medicinal Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Medicinal Chemistry Core Papers				
1.	MCH-331	Drug Design	60	4
2.	MCH-332	Chemotherapy I	60	4
Practical Courses				
1.	LMCH-331	Laboratory Course 1	120	4
2.	LMCH-332	Laboratory Course 2	120	4
1.	SMCH-331	Literature survey and Seminar	30	2

M. Sc. S. Y. Medicinal Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Medicinal Chemistry Elective Papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EMCH-331	Organic Spectroscopy	60	4
2.	EMCH-332	Drug metabolites	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 (OPCH-311)	Intellectual property rights	60	4

M. Sc. S. Y. Medicinal Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Medicinal Chemistry Core papers				
1.	MCH-431	Chemotherapy II	60	4
2.	MCH-432	Advanced Medicinal Chemistry	60	4
Practical Courses				
1	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8

M. Sc. S. Y. Medicinal Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Medicinal Chemistry Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EMCH-431	Novel Drug delivery system	60	4
2.	EMCH-432	Synthetic methods in organic chemistry	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_03 OPCH-411	Industrial safety and hazardous management	60	4

M. Sc. S. Y. Organic Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Organic Chemistry Core papers				
1.	OCH-341	Organic Reaction Mechanism	60	4
2.	OCH-342	Organic Synthesis	60	4
Practical Courses				
1.	LOCH-341	Laboratory Course 1	120	4
2.	LOCH-342	Laboratory Course 2	120	4
1.	SOCH-341	Literature survey and Seminar	30	2

M. Sc. S. Y. Organic Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Organic Chemistry Elective papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EOCH-341	Organic Spectroscopy	60	4
2.	EOCH-342	Chemistry of heterocyclic and biologically Active Molecules	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 (OPCH-311)	Intellectual property rights	60	4

M. Sc. S. Y. Organic Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Organic Chemistry Core papers				
1.	OCH-441	Advanced Organic Chemistry	60	4
2.	OCH-442	Bio- Organic chemistry	60	4
Practical Courses				
1	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8

M. Sc. S. Y. Organic Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Organic Chemistry Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EOCH-441	Chemistry of Natural product	60	4
2.	EOCH-442	Synthetic methods in organic chemistry	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_03 (OPCH-411)	Industrial safety and hazardous management	60	4

M. Sc. S. Y. Physical Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Physical Chemistry Core papers				
1.	PHCH-351	Solid State Chemistry	60	4
2.	PHCH-352	Advanced Quantum Chemistry	60	4
		Practical Courses		
1.	LPHCH-351	Laboratory Course 1	120	4
2.	LPHCH-352	Laboratory Course 2	120	4
1.	SPHCH-351	Literature survey and Seminar	30	2

M. Sc. S. Y. Physical Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Physical Chemistry Elective papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EPHCH-351	Organic Spectroscopy	60	4
2.	EPHCH-352	Statistical thermodynamics	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 (OPCH-311)	Intellectual property rights	60	4

M. Sc. S. Y. Physical Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Physical Chemistry Core papers				
1.	PHCH-451	Electrochemistry	60	4
2.	PHCH-452	Photochemistry	60	4
Practical Courses				
	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8

M. Sc. S. Y. Physical Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Physical Chemistry Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EPHCH-451	Biophysical chemistry	60	4
2.	EPHCH-452	Synthetic methods in organic chemistry	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_03 (OPCH-411)	Industrial safety and hazardous management	60	4

M. Sc. S. Y. Polymer Chemistry Core papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Polymer Chemistry Core papers				
1.	POCH-361	Fundamentals of Polymer Chemistry	60	4
2.	POCH-362	Polymer characterization and Testing	60	4
Practical Courses				
1.	LPOCH-361	Laboratory Course 1	120	4
2.	LPOCH-362	Laboratory Course 2	120	4
1.	SPOCH-361	Literature survey and Seminar	30	2

M. Sc. S. Y. Polymer Chemistry Elective papers (Third Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Polymer Chemistry Elective papers (any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EPOCH-361	Organic Spectroscopy	60	4
2.	EPOCH-362	Polymer physics	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_02 (OPCH-311)	Intellectual property rights	60	4

M. Sc. S. Y. Polymer Chemistry Core papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Polymer Chemistry Core papers				
1.	POCH-461	Structure property relationship in polymers.	60	4
2.	POCH-462	Polymers from Renewable resources.	60	4
Practical Courses				
1	ITCH-401/ RPCH -401	Industrial Training /Research Project (Skill Based)	240	8

M. Sc. S. Y. Polymer Chemistry Elective papers (Fourth Semester)

Sr. No.	Paper No.	Title	Contact hours	Credits
Polymer Chemistry Elective papers (Any one from the below or courses offered for any other program in school of chemical sciences)				
1.	EPOCH-461	Polymer processing technology	60	4
2.	EPOCH-462	Synthetic methods in organic chemistry	60	4
Open elective (any one)				
1.		Open elective from other schools	60	4
2.		MOOCS/SWAYAM/NPTEL courses	60	4
Open electives offered for students from other schools				
1.	OE_SES_03 (OPCH-411)	Industrial safety and hazardous management	60	4

M. SC. F. Y. (FIRST SEMESTER)

Course: Physical Chemistry (CH-101) **Credits 4 (60 Contact hours)**

Objectives:

- To understand the basic concepts, laws and postulates of quantum mechanics
- To understand the concept of wave functions and operators and to solve Schrodinger wave equation for rigid rotor, harmonic oscillator and for hydrogen atom
- To understand the concept of angular momentum and electronic structure of atoms
- To understand laws of thermodynamics, concept of partial molar properties and non-ideal systems
- To understand the distribution and thermodynamic probability and to discuss the partition functions and its significance
- To relate entropy production in different system and understand Onsager's relations
- To understand the adsorption and describe different adsorption models and application part of adsorption chemistry in diversified fields
- Develop skill in problems solving

Course contents:

1. Quantum Chemistry **20 Hrs.**

A) Introduction to quantum mechanics, blackbody radiation, Planck's hypothesis, Einstein's photoelectric effect, the spectrum of hydrogen atom, dual nature of matter, the Heisenberg uncertainty principle, Numerical.

B) Postulates of quantum mechanics, wave function, normalized and orthogonal wave functions, acceptability of wave functions, operators, discussion of solutions of the Schrodinger wave equation to systems such as particle in one dimensional box, the harmonic oscillator, vibrational energy levels, the rigid rotor, rotational energy levels, Numerical.

C) Angular momentum, magnitude of angular momentum, Eigen functions for angular momentum, Eigen values of angular momentum, spin antisymmetry and Pauli exclusion principle.

D) Schrödinger equation for hydrogen atom, spherical harmonics, precise values of angular momentum, hydrogen atomic orbital's, *s* orbital's, three *p* orbital's for $n >= 2$. Electronic structure of atoms, Russel-Sanders coupling schemes, term symbols, spin-orbit coupling and Zeeman splitting.

Home assignments:

Solution of the Schrodinger wave equation to particle in three dimensional box, degeneracy, time independent perturbation theory, variation method, quantum mechanical tunneling

2. Thermodynamics **20 Hrs.**

A) **Classical Thermodynamics:** Recapitulation of Laws of thermodynamics, partial molar properties, partial molar free energy, chemical potential, partial molar volume, partial molar heat content, determinations of partial molar volume, concept of fugacity and determination of fugacity by graphical method. Non-ideal systems: Activity, activity coefficient, Debye-Huckel theory for activity coefficient of electrolytic solutions, ionic strength, numerical on ionic strength.

B) **Statistical Thermodynamics:** Distribution, thermodynamic probability and most probable distribution. Ensemble: different types of ensembles, canonical, grand canonical and micro-canonical ensembles, Partition functions: molecular partition function, derivations of

translational, rotational, vibrational and electronic partition functions and numerical on partition functions.

C) Non-equilibrium Thermodynamics: Thermodynamic criteria for nonequilibrium states, entropy production in chemical reactions and entropy production due to heat flow, transformation properties of fluxes and forces, principle of microscopic reversibility and Onsager's reciprocity relations.

3. Surface Chemistry-I **20 Hrs.**

Adsorption: Introduction, physical and chemical adsorption, factors affecting adsorption, adsorption of gas on surface of solid-Langmuir adsorption isotherm, Freundlich adsorption isotherm, adsorption from solution-Gibbs adsorption isotherm, applications.

Home assignments: State functions, exact and inexact differentials, Euler reciprocal relations, chemical potential and its variation with temperature and pressure, thermodynamic properties in terms of partition function, entropy production and entropy flow in open systems, applications of irreversible thermodynamics to biological systems.

The BET theory of multilayer adsorption, modern techniques for surfaces

Recommended study materials (Books) :

1) Physical Chemistry-A Molecular Approach, Donald A. McQuarrie, Davis John D. Simon, Viva Books.
2) Introduction to Quantum Chemistry-A. K. Chandra, Tata McGraw Hill.
3) Quantum Chemistry-Ira N. Levine, Prentice Hall.
4) Physical Chemistry-P.W. Atkins, ELBS.
5) Principles of Physical Chemistry-Puri, Sharma, Pathania, Vishal Publishing Co.
6) Molecular quantum mechanics, Vol. I & II, P. W. Atkins, Oxford university presss.
7) Physical Chemistry by Alberty and Silby, Jolly Wiley.
8) Statistical thermodynamics by T. L. Hill, Addison Wesley.
9) Statistical Thermodynamics, Normand M. Laurendeau,
10) Chemical thermodynamics by F. T. Wall, W. H. Freeman & Co.
11) Physical chemistry - Robert J. Silbey, Robert A. Alberty, Moungi Gabriel Bawendi

Outcomes: The students will be able to

- Explain basic concepts, laws and postulates of quantum mechanics
- Describe different wave functions and operators
- The Schrodinger wave equation for the calculation of Energies of rigid rotor and harmonic oscillator and solve it for hydrogen atom
- Explain the concept of angular momentum
- Describe the electronic structure of atoms
- Good overview of laws of thermodynamics, partial molar properties for different systems and concept and examples of non-ideal systems
- Discuss concept distribution with examples, they will be able to explain most probable distribution and thermodynamic probability
- Concept of partition functions and its significance
- Can relate and explain the entropy production in different system and understand Onsager's relations
- Explain adsorption and relate the adsorption models and can use the knowledge of adsorption chemistry in different fields
- Solve problems related to quantum chemistry, will have large horizon of critical thinking and analytical reasoning

Course: Inorganic Chemistry (CH-102) Credits 4 (60 Contact hours)

Objectives:

- To study various approaches proposed to explain structures of simple molecules thoroughly.
- Tounderstand the difference between these approaches, to discuss each approach/model/theory to a sufficient detail.
- To understand the mechanisms operating behind substitution and redox reactions taking place in coordination complexes, the variety of factors affecting to substitution reactions.
- To know how to draw molecular orbital diagram for explaining bond formation in simple molecules as well as in coordination complexes.
- To learn how to explain the difference between sigma and pi bond formation in coordination complexes, the orbital's used in sigma and pi bond formation.

Course contents:

1. Stereochemistry and bonding in main group compounds 15 Hrs.

Introduction, VSEPR theory, postulates, examples, limitations, Walsh diagrams for triatiomic molecules (discussion related to BeH_2, H_2O & BeF_2), $d\pi$-$p\pi$ bond, examples, Bent rule and energetics of hybridisation, simple reactions of covalently bonded molecules (atomic inversion, Berry rotation, nucleophilic displacement & free radical mechanism)

2. Reaction mechanism (Part I) 15 Hrs.

Reaction mechanism in transition metal complexes: Introduction, Labile & inert complexes, Henry Taube's explaination of lability and inertness, Kinetic aspects of VBT & CFT, Stability, thermodynamic & kinetic stability of complexes, Factors affecting stability of complexes (related to properties of metal ion and ligand), stepwise and overall stability constant and relationship between them

Ligand substitution reactions in octahedral complexes: Introduction, SN^1& SN^2 mechanism, Acid hydrolysis & factors affecting acid hydrolysis, Base hydrolysis, SN^2 mechanism for base hydrolysis, Base hydrolyis by conjugate base (SN^1CB) mechanism, Indirect evidences in favour of SN^1CB mechanism.

3. Reaction mechanism (Part II) 15 Hrs.

Ligand substitution reactions in square planar complexes: Introduction, Trans effect, Theories of trans effect (Grinberg's polarisation theory and pi-bonding theory), Applications of trans effect, Mechanism of substitution reactions in square planar complexes, Factors affecting rate of substitution reactions in square planar complexes.

Reduction-oxidation reactions in complexes: Introduction, Classification of reduction-oxidation reactions, Inner sphere mechanism & examples, main characteristics of inner sphere mechanism, Outer sphere mechanism & examples, main characteristics of outer sphere mechanism.

4. Molecular Orbital Theory 15 Hrs

Molecular orbital theory for simple molecules: Introduction, Linear combination of atomic orbitals (LCAO), Conditions for effective combination of atomic orbitals, mixing of orbitals, rules for adding electrons in moleuclr orbitals, Molecular orbital diagrams for homonuclear diatomic (from H_2 to Ne_2) molecules, Molecular orbital diagrams for heteronuclear diatomic molecules (CO, NO, HF & HCl), Comparison of bond orders and stability in various diatomic molecules

Molecular orbital theory for coordination complexes: Recap of CFT,limitations of CFT & Nephelauxatic effect, Assumption of MOT for octahedral complex formation, Ligand group orbital's (LGO) with respect to octahedral complexes (with diagrams), Ligand group orbital's (LGO) with respect to tetrahedral complexes (without diagrams), Molecular orbital

diagrams for sigma bonding in complexes (octahedral, tetrahedral and square planar complexes), Pi bonding in complexes, Molecular orbital diagrams for pi bonding in complexes (octahedral, tetrahedral and square planar complexes), Evidences for Pi bond formation in metal complexes (Crystallographic and IR spectroscopic evidence).

Home assignments:

a. Basic coordination chemistry, Werner's theory, valence bond theory, explanation of structure of complexes based on VBT, limitations of VBT.

b. Life history of Nobel laureates (Their research should be focused more, mentioned in this course paper only).

c. Basic information regarding equivalent weight, normal, molar, and percentage solution. Preparation of Solutions.

d. Lab safety, use of various mineral acids in lab safely, MSDS data sheets collection and understanding safety measures in the laboratory.

Recommended Study Materials (Books)

1) Inorganic Chemistry (Principles of structure and Reactivity), 4th edition, James Huheey, Eller A. Keiter, Richard L. Keiter. Harper Collins College Publishers.
2) Selected Topics in Inorganic Chemistry. W. U. Malik, G.D. Tuli, R. D. Madan. S. Chand Publications.
3) Advanced Inorganic Chemistry Vol I. Gurdeep Raj. Goel Publishing House.
4) Principles of Inorganic Chemistry. B. R. Puri, L. R. Sharma and K. C. Kalia. Milestone Publishers & Distributors.
5) Advanced Inorganic Chemistry. Satish Kumar Agarwal & Keemti Lal. Pragati Prakashan
6) Advanced Inorganic Chemistry, (A comprehensive text). F.A. Cotton and G. Wilkinson, Interscience Publishers, John Wiley & Sons.
7) Inorganic Chemistry, 5th edition. Shriver and Atkins. W. H. Freeman and Company, New York.
8) Comprehensive Coordination Chemistry. Eds. G. Wilkinson, R. D. Gillars and J. A. McCleverty, Pergamon.

Outcomes: Student will be able to

- Learn various approaches in analyzing structures of simple molecules.
- Understand the proposed pathways for reactions taking place incoordination complexes such as substitution reactions, redox reactions etc. and the variousfactors affecting to rates of these reactions.
- Learn about mechanisms proposed for reactions taking place in coordination complexes, and will be able to understand to explain the product formation based on these mechanisms.
- Understand how to construct molecular orbital diagrams for simple molecules as wellas coordination complexes.
- Draw molecular orbital diagrams for sigma and pi bond formation incoordination complexes and will be able to understand and explain the difference betweenrespective molecular orbital diagrams.

Course: Organic Chemistry (CH-103) Credits 4(60 Contact hours)

Objectives:

- Students should learn about Nature of Chemical bonding in Organic molecules, Structure and Reactivity.
- To understand the various concept of Stereochemistry, Asymmetric synthesis, absolute configuration and Conformation analysis.
- To explain the mechanism of aliphatic electrophilic and nucleophilic substitution reactions.
- To interpret the problems of Benzenoid and Non Benzenoid compounds.
- Students develop the knowledge of Thermodynamic of the reaction and Kinetic of the reactions
- Student should explain the Free radical mechanism.
- To develops skill of writing mechanism.

Course contents:

1.Nature of Bonding in Organic Molecules 10 Hrs.

a) Chemical bonding and reactivity- Chemical bond, delocalization, Conjugation, resonance, hyper conjugation, tautomerism, inductive effects, sterric effect.

b) Bonding other than covalent bonding: Ionic, hydrogen bond, inclusion compounds, rotaxanes, catenanes, cyclodextrins, cryptands, fullerenes, crown ethers.

c) The relation between structure and acidity and basicity

d) Aromaticity: Benzenoid and non-benzenoid compounds, Huckels rule, antiaromaticity, homo aromaticity. Application to carboxylic and heterocyclic systems, annulenes, azulenes

2. Reaction Mechanism: structure and activity 10 Hrs.

a) Elementary and simple reaction, Hammond postulate, Molecularity, Energy profile diagram.

b) Thermodynamics of the reaction, kinetic of the reaction, thermodynamic verses kinetic control of reactions, Hammett and Taft effect.

c) Kinetic isotopic effects, method of determining reaction mechanism

d) Structure and stability of reactive intermediates, carbenes, nitrenes, carbocations, carbanions, benzynes, ylides, enamines and free radicals.

3. Stereochemistry 15 Hrs.

a) Concept of chirality and molecular dissymmetry.

b) Symmetry elements and chiral centres, Prochiral relationship, homotopic, enantiotopic and disteriotopic groups and faces.

c) Recemic modifications and their resolution, R and S nomenclature. Geometrical isomerism E and Z. nomenclature.

d) Steriospeciffic and sterioselective reactions.

e) Asymmetric synthesis, optical activity in absence of chiralcarbon, biphenyl, allenes and spiranes, Chirality due to helical shape.

f) Conformational analysis: Cyclohexane (mono and disubstituted i.e. halo, hydroxyl and methyl) and decalins, stability and reactivity.

4.Substitution Reactions 15 Hrs.

A) Aliphatic Nucleophilic

a) Types of Aliphatic nucleophilic substitution Reactions-SN1, SN2, SET mechanism,

b) NGP by pi and sigma bonds, classical and non-classical carbocations, phenonium ions, norbornyl system, carbocation rearrangement in NGP, SNi mechanism,

c) Effect of structure, nucleophile, leaving group, solvent on rate of SN1 and SN2 reactions, ambient nucleophile, Phase transfer catalysis and regioselectivity.

B) Aliphatic Electrophilic

a) Types of Aliphatic electrophilic substitution reaction: SE1, SE2, SEi.
b) Electrophilic substitution accompanied by double bond shift.
c) Effect of substrate, leaving group and solvent polarity on the reactivity

5. Free Radical Reaction **10 Hrs.**

a) Generation, characterization and stability of free radicals.
b) Free radical mechanism, NGP in free radical reactions.
c) Reactivity for aliphatic and aromatic substrate at bridge head.
d) Hundsdiecker reaction

Home assignments - Anomeric effect, angle strain and its effect on reactivity, effect of conjugation on reactivity, stereochemistry of compounds containing N, P and S, confirmation of acyclic molecules, isotopes in labelling experiments, Reed reaction, Diazo transfer reaction, esterification and ester hydrolysis. Hard and soft acid bases concept. Beckman rearrangement, rearrangement fragmentation of free radical reaction

Recommended study materials (Books):

1. Advanced organic chemistry-Reaction mechanism and structure, Jerry March, Jhon Wiley.
2. Structure and mechanism in organic chemistry, C. K. Ingold, Cornell University Press.
3. Advanced organic chemistry, F. A. Carey and R. J. Sundberg, Plenum.
4. A guide book to mechanism in organic chemistry, Peter Sykes, Longman.
5. Stereochemistry of organic compounds, D. Nasipuri, New Age International.
6. Reaction mechanism in organic chemistry, S. M. Mukherji and S. P. Singh, Macmilan.
7. Modern organic reactions , R. O. C. Norman and J. M. Coxon, Blackie Academic and Professional.
8. Organic chemistry, R. T. Morison Boyd, Prentice-Hall.
9. Stereochemistry of organic compounds, P. S. Kalsi, New Age Intrenational.
10. Modern organic reactions, H. O. House, Benjamin.

Outcomes:Student will be able to

- Understand the various types of Reaction Mechanism.
- Adopt the concept of Bonding in Organic Molecules.
- Learn the concept of Stereochemistry and to identify the Stereo chemical reactions.
- Explain the various problems of aromaticity, homoaromaticty and antiaromaticity.
- Familiarize the various types of Substitution reactions and their mechanism
- Gain the knowledge of free radical reactions.
- Justifies the various effect of substrate.

Course: Basic Principals of Spectroscopy (CH-104) Credits 2(30 Contact hours)

Objectives:

- This course aims to introduce the basic principles of molecular spectroscopy
- To understand how of electromagnetic radiations in certain region energy interact with the matter.
- To understand the factors governing the distinctive spectra of a compounds in UV-vis, IR and microwave region.
- To interpret the rotational, vibration and electronic spectra of simple molecules.

Course contents: **05 Hrs.**

1. Unifying Principles

Characterization of electromagnetic radiation, quantization of energy, regions of the spectrum, interaction of radiation with molecular systems, types of molecular energies, factors affecting width and intensity of spectral lines, selection rule, general discussion on various molecular excitation processes.

2. Microwave spectroscopy **05 Hrs.**

Classification of molecules according to their moment of inertia, rigid rotor model, effect of isotopic substitution on the transition frequencies, stark effect, non-rigid rotor, selection rules, mechanism of interaction, spectra of symmetric and asymmetric top molecules, applications of microwave spectroscopy.

3.Infrared spectroscopy **10 Hrs.**

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and band strengths, anharmonicity, morse potential energy diagram, vibration-rotation spectroscopy, PQR branches, Breakdown of oppenheimer approximation, vibrations of polyatomic molecules, selection rules, normal modes of vibrations, overtones, hot bands, finger-print region, functional group identification.

4. Raman spectroscopy **05 Hrs.**

Classical and quantum theory, Raman effect, Stokes and antistokes lines, pure rotational, vibrational and rotation-vibration Raman spectra, selection rules, mutual exclusion principles, structure determination of di-, tri- and tetra-atomic molecules from Raman and IR spectra, effect of polarization of light.

5. Atomic and molecular electronic spectroscopy **05 Hrs.**

Atomic transitions, spin orbit interaction, atom in uniform magnetic field, many electron atoms, spectra of alkali/alkaline earth atoms, molecular electronic transition, vibrational coarse structure, intensity/selection rule, Frank-Condon Principles, ground and first excited electronic states of diatomic molecule, dissociation energy and dissociation products, rotational fine structure, Fortrat diagram, predissociation

Home assignments: Numerical problems, objective questions and some latest research articles.

Recommended study materials (Books):

1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", Mc Graw Hill.
2. P. S. Sindhu, "Elements of Molecular Spectroscopy", New Age International publisher, New Delhi (2010).
3. B. Narayan, "Fundamentals of Spectroscopy", Allied Publishers Limited, New Delhi (1999).
4. J. M. Hill, "Modern Spectroscopy", John Wiley & Sons Ltd, (2004).
5. N. N. Greenwood, J. W. Akitt, W. Errington, T. C. Gibb, and B. P. Straughan, "Spectroscopic Properties of Inorganic and Organometallic Compounds" The Chemical Society, London, 1968.
6. P. R. Bunker, P. Jensen, "Molecular Symmetry and Spectroscopy", Overseas Press India Ltd., New Delhi (2005).
7. R. S. Drago : Physical Methods for Chemists (2nd Edn.)
8. R. Chnag : Basic Principles of Spectroscopy.

9. F. C. Gibb : Principles of Mossbauer Spectroscopy.
10. C.N.R. Rao : Chemical Application of Spectroscopy in Inorganic Chem.
11. G.M. Barrow - Molecular Spectroscopy.
12. M. Chander - Atomic Structure, Chemical bonding including Molecular Spectroscopy.
13. An introduction to Electron Paramagnetic Resonance, M. Bersohn & J.C.Baired, W.A.Benjamin , Inc N.Y. (1966) 2. High resolution ESR Spectroscopy F. Gerson,(John Wiley & sons– 1970)
14. Nuclear Quadrupole Resonance in chemistry, G.K.Semin,T.A.Babushkina & G.G. Yakobson, John Wiley & sons,(N.Y.)-(1975)

Outcomes:Students will be able to

- Explain the basic principles of rotational, vibrational, electronic and Raman spectroscopy.
- Identify and explain factors that influence the strength and frequency of peaks in the Microwave, IR, and UV-vis spectra.
- Describe the selection rule for rotational, Vibrational and electronic spectroscopy.
- Determine the vibrations for a molecule and identify whether they are active in infrared and/or Raman spectroscopy.
- Explain the difference between Stokes and anti-Stokes lines in a Raman spectrum and justify the difference in intensity between Stokes and anti-Stokes lines.
- Draw the Stokes and anti-Stokes lines in a Raman spectrum of a compound when given the energies of the different transitions.
- Understand the electronic spectra of atomic and diatomic molecular systems.
- Justify the absorption lines in atomic electronic spectra and the broad bands in molecular electronic spectra.
- Able to interpret the molecular electronic spectra and deduce the electronic structure information in ground and excited states of diatomic molecules.

Course: Symmetry and Group Theory (CH-105) Credits 2(30 Contact hours)

Objectives:

- To introduce the concepts of symmetry.
- Study the concept of group theory for understanding molecular representations,
- To provide an introductory treatment of bonding theories, electronic and vibrational spectroscopy.
- Molecular Symmetry, Symmetry operations and symmetry elements: Plane of symmetry, Proper/Improper Axis of symmetry, Inversion center, Identity element.
- Necessary conditions for any set of elements to form a Group, Properties of a group, Subgroups, Classes in a group. Types of Groups, Abelian and Non-Abelian group. Product of Symmetry operations, Group Multiplication table.
- Molecular point groups, Schoenflies symbol, Point group classifications.
- Matrices, Matrix representation of Symmetry operations, Character of a matrix, Matrix representation of point group.
- Representations: Reducible and Irreducible representations. The Great Orthogonality Theorem (without proof) and its importance, properties of irreducible representations.
- Character tables, Construction of character tables for C_{2V}, and C_{3V} point groups, Mulliken symbols.

Course contents:

1. Applications: 30 Hrs.

a) Dipole and Optical activity.
b) Use of group theory in predicting IR and Raman active modes in some simple molecules of C_{2V}, C_{3V} and D_3h etc. point groups.
c) Electronic spectra. **Home assignments** : Problems.

Recommended study materials (Books):

1. Chemical Applications of Group Theory, F.A. Cotton, John Wiley
2. Physical Methods for Chemistry, R.S. Drago, Saunders Compnay.
3. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS.
4. Infrared and Raman Spectral : Inorganic and Coordination Compounds K. Nakamoto, Wiley.
5. Group theory and its chemical applications: P.K Bhattacharya, 2nd edn, Himalaya pub. India.
6. Molecular symmetry and group theory -A. Vincent.
7. Symmetry in Chemistry: H.H.Jaffe' and M.Orchin, Dover Publications Inc, New York,

Outcomes: Students will be able to

- Understand how to recognize symmetry elements in a molecule.
- Assign the point group to a molecule.
- Deal with degenerate and non-degenerate representations.
- Predict the Optical activity of molecules.
- Shall be able to interpret IR, Raman and Electronic spectra in context to its molecular symmetry.
- Selection rules and also applying orbital symmetry to chemical reactions.

Course: Laboratory Course-1:(Physical Chemistry:LCH-101)Credits 4(120 Contact hours)
Objectives:

- To understand basic principles and theory of different instruments
- To perform different experiments on conductometer, pH meter, potentiometer, calorimeter, polarimeter, refractometer
- To set various experiments based on the different instrumentations
- To understand basic principles and theory of measurements of density, viscosity, refractive index, surface tension, adsorption
- To perform different qualitative and quantitative analysis.

Section-A: Instrumentation (any eight)

1. To determine velocity constant and energy of activation for saponification of ethyl acetate by NaOH conductometrically.
2. To determine the relative strength of chloroacetic acid and acetic acid conductometrically.
3. To determine equivalent conductivity of strong electrolyte at several concentrations and to verify Onsager's equation.
4. To determine the solubility and solubility product of sparingly soluble salt, [$BaSO_4$/$PbSO_4$] at different temperatures conductometry.
5. To determine potentiometrically the pK_1 and pK_2 values of H_3PO_4
6. To determine Hammett constant of given substituted benzoic acid using pH-meter.
7. To determine pH values of various mixtures of sodium acetate and acetic acid in aqueous solution and hence find out dissociation constant of acid.
8. To determine concentration of Cu (II) ion in given solution titrating with EDTA solution by calorimetry.
9. To determine the relative strength of two acids by polarometry.
10. To study the variation of refractive index with composition of mixtures of CCl_4 and ethyl acetate.(Any other related experiments may be added)

Section-B: Non Instrumental (any eight)

1. To determine partial molar volume of ethanol and water mixture at given composition.
2. To determine molecular weight of high polymer by viscosity measurements.
3. To study the effect of surfactant on surface tension of water by using stalagmometer.
4. To determine the viscosity of mixtures by Ostwald's viscometer.
5. To determine the solubility of benzoic acid at different temperature and hence to determine its heat of solution.
6. To construct the phase diagram of three component system. [$CHCl_3$, CH_3COOH and H_2O]
7. Investigate the autocatalytic reaction between $KMnO_4$ and oxalic acid.
8. To determine the rate constant of hydrolysis of ester [catalyzed by NaOH/HCl]
9. To investigate the adsorption of (oxalic acid/acetic acid) by activated charcoal and to test the validity of Freundlich and Langmuir isotherm.
10. To study the surface tension concentration relationship for the solution.(Any other related experiments may be added)

Recommended study material:

1. Practical Physical Chemistry: B. Viswanathan and P.S. Raghavan
2. Findley's Practical Physical Chemistry, B.P. Levitt Longman.
3. Practical Physical Chemistry, A.M. James and F.F. Prichanrd Longman.

4. Experimental Physical Chemistry, R.C. Das and B.Behra, Tata McGraw Hill.
5. Experimental Physical Chemistry, V.D. Athanale and Parul Mathur New age International
6. Systematic experimental Physical Chemistry by Dr. T.K. Chandhekar & S.W. Rajbhoj.
7. Advance Practical Physical Chemistry J.B. Yadao Goel Pubs. House.
8. Experimentals in Physical Chemistry by Dr. D.V.Jahagirdhar.
9. Experiments in Physical Chemistry by D.P.Shoemaker.

Outcomes: Student will be able to

- Understand the basic principles and theory of different instruments used during the conduction of the experiments
- Perform the different experiments on conductometer, pH meter, potentiometer, calorimeter, polarimeter, refractometer
- Apply their knowledge for setting various experiments based on the instrumentations studied
- Understand the basic principles and theory of measurements of density, viscosity, refractive index, surface tension, adsorption etc.
- Perform different qualitative and quantitative analysis.

Course: Laboratory course-2:(Inorganic Chemistry:LCH-102)Credits 4 (120 Contact hours)
Objectives:

- To correlate the theoretical aspects taught in the classroom with practical observation such as coordination number, oxidation state of metal present, magnetic nature of complexes etc.
- To understand structure determination of coordination complexes with the help of various techniques such as IR, electronic spectra, magnetic properties and molar conductance measurements etc.
- To understand the role of various factors in structure determination of coordination complexes, the operating procedures and principles lying behind applications of various analytical techniques in determination of structure of complexes.
- To learn the basic principles involved in the analysis of inorganic mixtures such as acidic and basic radicals, sodium carbonate extract, its preparation and use while analysis, original solution, its preparation and use, group reagents, spot test reagents and their use while analyzing inorganic mixture, solubility product, common ion effect etc
- To understand the reactions taking place while analyzing various acidic and basic radicals in a given mixture and to deepen the level of understanding of inorganic chemistry.

List of Laboratory Experiments

A) Preparation and characterization of complexes. (**Any six**)
   (a) Vanadium acetylacetonate $VO(acac)_3$
   (b) Manganese acetylacetonate $Mn(acac)_3$
   (c) Potassium trioxalato ferrate(III) $K_3[Fe(C_2O_4)_3]$
   (d) Hexammine nickel(II) chloride $[Ni(NH_3)_6Cl_2]$
   (e) Hexammine Cobalt(III) Chloride $[Co(NH_3)_6Cl_3]$
   (f) Tetrammine Copper(II) sulphate $[Cu(NH_3)_4SO_4]$
   (g) Cis-Potassium dioxalatodiaquochromate Cis-$K[Cr(C_2O_4)_2(H_2O)_2]$
   (h) Chloropentammine cobalt(III) chloride $[Co((NH_3)_5Cl)Cl_2]$
   (i) Mercury(II) tetrathiocyanatocobaltate(II) $[HgCo(SCN)_4]$

B) Semi-micro Qualitative analysis of inorganic mixtures **(Any 6 mixtures**)
   (Detection of three acidic radicals and three basic radicals)

Recommended Study Materials (Books & Laboratory manuals)

1) Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis (Fifth edition). **G. Svehla.** Longman Group Limited, London (1979).
2) Advanced Practial Inorganic Chemistry. **Gurdeep Raj.** Goel Publishing House,India, (2013).
3) Practical Inorganic Chemistry. **Shikha Gulati, J. L. Sharma, Shagun Manocha**. CBS Publishers & Distributors Private Limited, India (2017).
4) Practical Inorganic Chemistry. **Amita Dua, Dr. Navneet Manav**. Manakin Press Private Limited, New Delhi, India (2016).
5) Practical Inorganic Chemistry: Preparations, reactions and instrumental methods (Science Paperbacks) 2nd Edition. **G. Pass.**Springer publication, July 1979 (**ISBN-10:** 0412161508, **ISBN-13:** 978-0412161506)
6) Lab Manual Advanced Inorganic Chemistry Laboratory. **Michael J. Prushan**, Department of Chemistry and Biochemistry, La Salle University (2002-2003).
7) Laboratoty Manual of Practical Inorganic II Chemistry. **M. Pranjoto Utomo**, Department of Chemistry Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, (2011).

Outcomes: Students will be able to

- Learn synthesis methods for the preparation of various coordination complexes and will understand the basic principles involved in operational procedures while synthesizing the complexes to a deeper level.
- To characterize a synthesized complex using various characterization techniques such as melting point determination, solubility behavior in various solvents, molar conductance, magnetic susceptibility measurements, IR and electronic spectra etc.
- While following all these methods he/she will be able to understand operation procedures, care that should be taken while using these techniques and the practical utility of these techniques.
- Understand the basic principles lying behind inorganic analysis such as precipitation, solubility product, buffer solution, applications of buffer solution in maintaining pH, common ion effect etc. and this much information will be helpful while analyzing any inorganic compound in future.
- Correlate the theoretical knowledge gained at graduate or postgraduate level with the practical observations and will be able to reproduce it when needed.

Course: Seminar (SCH - 101) **Credits 1 (15 Contact hours)**

Objectives:

- To enhance the presentation skill and stage courage
- To provide the platform to the students to express them
- To be able to prepare the report component and structure
- To increase knowledge of students in the specific subject

Outcomes:

1. The presentation skill and stage courage of the students will be enhances
2. This activity will provide the platform to the students to express them
3. Students will be able to prepare report component and structure
4. The knowledge of students in the specific subject will be enhanced

OE_SES_01 (OCH-101) : Lab Safety **Credits-2(Contact hours30)**

Objectives:

- Demonstrate working knowledge of laboratory safety
- To learn to tackle the laboratory emergencies, chemical hazards, lab inspections and compliance, managing and working with chemicals
- Ability and knowledge of safe laboratory techniques and waste disposal

Course contents:

1. Introduction to Laboratory Safety **10 Hrs**

I. Introduction
The Bhopal gas incidence (Lessons to be learned: Shared Responsibilities)

II. Risks in a chemical Laboratory
Health Effects Due to "Hazardous" Chemical Exposure (How Does One Determine the Hazards Associated with Specific Chemicals?, Exposure Routes, Toxicity Risk Assessment)

III. Personal Protective Equipment (PPE)
Proper Attire (Eye/Face Protection, Lab Coats, Gloves, Respirators, Disposal/Removal of PPE)

IV. Emergency Equipment Safety Showers/Eye Washes

V. Key Campus and Department Chemical Safety Contacts

VI. Case studies of chemical incidences

2. Laboratory Emergencies: Spills and Fires& chemical hazards **10 Hrs**

I. General Preparation for Emergencies

II. Handling the Accidental Release of Hazardous Materials, notifications

III. Spill Containment and Clean-up V. Leaking Gas Cylinders

IV. Fires Classification, Fire Extinguishers (how they work, types),

V. Chemical Hygiene Plan, the Material Safety Data Sheets (MSDS), Assessment of Chemical Toxicity, Toxic Hazards (Dose, Risk Assessment, Types of Toxins, Flammable Hazards, Flammability Characteristics,
Flammability Classes, Causes of Ignition, Reactive Hazards, Explosives)

VI. Case studies of incidences

3.Managing and Working with Chemicals and waste handling **10 Hrs**

I. Working with Flammable Substances (Standard Operating Procedures)

II. Working with Highly Reactive or Explosive Substances

III. Working with Compressed Gases (Parts of the Cylinder, Cylinder Pressure Regulator, Storage Guidelines, Transporting Cylinders, Handling Compressed Gas Cylinders)

IV. Characterization of Waste

V. Collection and Storage (Lids, Leaks, Labels, Location, Containers) III. Consequences of Mixing Incompatibles

VI. Solid Wastes (Chemicals, Broken Glass, Sharps, Cylinders, Pick-up) VI. Special Cases

VII. Hazardous Waste Minimization

Recommended Study Materials (Books)

- Safety in academic chemical laboratories Volume 1 A publication of American Chemical Society joint board with council committee on chemical society seventh edition (2003) ISBN 0-8412-3663-4
- Occupational Health and Safety Administration (OSHA) Preamble: http://www.osha.gov/dte/grant_materials/fy07/sh-16625-07/cshandout.pdf
- Occupational Health and Safety Administration (OSHA) Bloodborne Pathogens Standard: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10051
- Laboratory Standard: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10106

Outcomes:

- Students will adopt the skill of lab safety for their health. They will be able to apply their knowledge of lab safety to avoid accidents, injuries

M. SC. F. Y. (SECOND SEMESTER)

Course: Physical Chemistry (CH-201) Credits 4 (60 Contact hours)

Objectives:

- To understand concepts and properties of surfactants and macromolecules
- To state laws, principles, theories related to the electrochemistry of the solutions
- To discuss and understand the corrosion, its monitoring and presentation
- To discuss different theories of reaction rates
- To understand the kinetics of complex reactions, catalysis etc.
- To perform the calculations and solve the numerical of electrochemistry and chemical kinetics
- To develop skill in problems solving, critical thinking and analytical reasoning

Course contents:

1. Surface Chemistry and macromolecules 20 Hrs

A) **Micelles:** Recapitulation of surface tension, Surface active agents, classification of surface active agents, hydrophobic interactions, micellisation, critical miceller concentration (CMC), factors affecting CMC of surfactants.

B) **Macromolecules:** Definition of macromolecule **(**Polymers), classification of polymers, number average and mass average molecular mass of polymers, molecular mass determination of polymers by viscometry and light scattering methods, numerical.

Home assignment: Shape and structure of micelles, thermodynamics of micellization, electronically conducting polymers

2. Electrochemistry of solutions: 20 Hrs

A) Debye-Huckel-Onsager treatment, ion solvent interactions, thermodynamics of electrified interface, Lippmann equation, over potential, exchange current density, derivation of Butler-Volmer equation, Tafel plot, quantum aspects of charge transfer at electrodes-solution interfaces, tunnelling.

B) **Semiconductor/electrolyte interface:** Theory of double layer at semiconductor/electrolyte interface, structure of double layer interface, flatband potential, effect of light at semiconductor solution interface.

C) **Polarography:** Principle, theory and applications of polarography, Ilkovic equation, numerical, diffusion current and half wave potential and their significance.

D) **Corrosion:** Introduction, corrosion monitoring and corrosion prevention techniques.

Home assignment: Structure of electrified interfaces, Helmholtz-Perrin model, Gouy-Chapman model and Stern model, derivation of Ilkovic equation from Fick's laws of diffusion

3. Chemical Kinetics 20 Hrs

A) **Theories of reaction rates:** Introduction, methods of determining rate laws, bimolecular reactions: Collision theory of reaction rates in gas phase, energy requirement, steric factor, Activated complex theory (Transition state theory), assumptions, Arrhenius equation. Unimolecular reactions: Lindemann theory of unimolecular reactions, numerical.

B) **Reactions in solution:** Introduction, reactions in solutions, solvent effects on reaction rates, diffusion controlled reactions, ionic reactions and salt effect. Concept of steady state approximation.

C) **Kinetics of complex reactions:**Dynamics of chain reactions (hydrogen-bromine reaction, pyrolysis of acetaldehyde), photochemical (hydrogen-bromine and hydrogen-chlorine).

D) **Catalysis and study of fast reactions:** Catalysis: Introduction, acid-base catalysis and enzyme kinetics, mechanism of enzyme catalysis, active sites, Michaelis-Menten equation. Fast reactions: General features of fast reactions, study of fast reaction by flow methods and flash photolysis.

Home assignments: Hinshelwood theory for unimolecular reactions, RRKM theory, kinetics of complex reactions, opposing reactions, consecutive reactions, potential energy surfaces

Recommended study materials Books):

1. Micelles, Theoretical and Applied Aspects-V. Moroi, Plenum.
2. Physical chemistry of macromolecules, S. F. Sun, John-Wiley and Sons, INC.
3. Introduction to Polymer Science-V. R. Gowarikar, N, V. Vishwanathan & J. Sridhar, Wiley Eastern.
4. Modern Electrochemistry Vol. I & II, J. O. M. Bockris & A. K. N. Reddy, Plenum.
5. Principles of Physical Chemistry-Puri, Sharma, Pathania, Vishal Publishing Co.
6. Physical Chemistry-P. W. Atkins, ELBS.
7. Introduction to Quantum Chemistry-A. K. Chandra, Tata McGraw Hill.
8. Quantum Chemistry-Ira N. Levine, Prentice Hall.
9. Coulson's Valence-R. Mc Weeny ELBS.
10. Chemical Kinetics-K. J. Laidler, McGraw Hill.
11. Kinetics and Mechanism of Chemical Transformations-J. Rajaraman and J. Kuriacose, Macmillan.

Outcomes:Students will be able to

- Understand the basic concepts and properties of surfactants and macromolecules
- State and apply different laws, principles, theories related to the electrochemistry of the solutions.
- Discuss and apply the information about corrosion, its monitoring and presentation.
- Distinguish different theories of reaction rates.
- Understand the kinetics of complex reactions, catalysis etc.
- Perform the calculations and solve the numerical of electrochemistry and chemical kinetics.
- Develop skill in problems solving, critical thinking and analytical reasoning.

Course: Inorganic Chemistry (CH-202) Credits4(60Contact hours)

Objectives:

- To understand the basic concepts regarding electronic spectra of coordination complexes such as energy levels in an atom or molecule, term symbol, derivation of term symbol, Orgel diagrams, T-S diagrams, Racah parameters and various factors affecting to electronic spectra of coordination complexes etc.
- To understand magnetic nature of coordination complexes, diamagnetic and paramagnetic complexes, measurement of magnetic moments of coordination complexes, Guoy's balance and its operational procedure and difference between diamagnetic and paramagnetic complexes etc.
- How to predict magnetic nature of coordination complexes using spin only formula, anomalous magnetic moment, spin cross over phenomena etc.
- To understand carbonyl and nitrosyl complex chemistry, bonding patterns present in these complexes, structures and properties of various carbonyl and nitrosyl complexes and applications of these complexes.
- To understand the chemistry of boranes/carboranes and metal clusters, bonding pattern present in clusters, multiple metal-metal bond formation in metal clusters etc.

Course contents:

1. Electronic spectra & Magnetic properties of transition metal complexes 15 Hrs

Electronic spectra of transition metal complexes: Introduction, coupling of orbital angular momentum and spin angular momentum, spin-orbit coupling, coupling schemes (Russell Saunders coupling and j-j coupling), Term symbol, Hund's rules for determination of ground state term symbol, Prediction of ground state term symbol for various configurations, Microstates, calculation of number of microstates and problems, Hole formulation, Racah parameters, Effect of weak octahedral and tetrahedral crystal field potential on terms, Orgel diagrams (plotting of Orgel diagrams for d^1-d^9 configurations), Tanabe-Sugano (T-S) diagrams (for d^2& d^6 configurations only), Selection rules & relaxation in selection rules, charge transfer spectra, Interpretation of electronic spectra of transition metal aqua complexes.

Magnetic properties of transition metal complexes: Introduction, Prediction of magnetic moment values of transition metal complexes (d^1-d^9 configurations) using spin only formula, Anamalous magnetic moments and spin crossover, Problems based on magnetic properties of complexes.

2. Metal carbonyls & Nitrosyls 15 Hrs

Metal carbonyls: Introduction, Classification of carbonyl complexes, Formation of CO molecule, Coulson's modification and explanation of strong field effect of Co ligand, Bonding in metal carbonyl complexes (mono, di & trinuclear carbonyl complexes, synergic relationship between metal and CO ligands), Preparation, properties & structures of mono, di & trinuclear carbonyl complexes [$V(CO)_6$, $Cr(CO)_6$, $Ni(CO)_4$, $Fe(CO)_5$, $Mn_2(CO)_{10}$, $Co_2(CO)_8$, $Fe_2(CO)_9$, $Fe_3(CO)_{12}$], EAN rules for metal carbonyls and problems based on EAN, 18 electron rule for metal carbonyls and problems based on 18 electron rule.

Metal nitrosyls: Introduction, Classification of metal nitrosyls, Linear v/s Bent nitrosyls, Preparation, properties, structure & applications of sodium nitroprusside (SNP), Brown ring compound, EAN rules for metal nitrosyls and problems based on EAN.

3.Boranes, Carboranes and Metal clusters **15 Hrs**

Introduction, Classification & nomenclature of boranes, Preparation, properties & Structure of B_2H_6, Chemistry of $C_2B_{10}H_{12}$ (Di-carbacloso-dodecacarborane), Wade's rules for prediction of structure type in boranes and carboranes, styx code (determination of styx code for B_2H_6, B_4H_{10}, B_5H_9, B_5H_{11}& B_6H_{10} molecules by drawing their structures), Problems based on Wade's rules.

Introduction to metal clusters, Classification of metal clusters, Structures of Carbonyl Clusters (LNCC), Structural aspects of Halide type Clusters (Di, tri, tetra & hexanuclear clusters), Cheverel phases and Zintl ions, Wade's rules for total electron count in HNCC & problems based on it.

4.Inorganic Catalysis: 15 **Hrs**

Introduction, general principles& mechanism of catalytic reactions, types of catalysts (6 types-positive, negative, auto, induced, enzyme, acid-base catalyst). Homogenous catalysis: Hydrogenation of alkenes, hydroformylation reaction, methanol carbonylation reaction, Wacker oxidation of alkenes, Pd catalyzed C-C bond formation reaction. Heterogeneous catalysis-The nature of heterogeneous catalysis, ammonia synthesis, SO_2 oxidation, Fischer-tropsch synthesis, alkenes polymerization, new direction in heterogeneous catalysis such as Tethered catalysis

Home assignments:

1. Essential metals in biological systems such as Na, K, Ca, Mg etc. and their role.
2. Information about hemoglobin, myoglobin, synthetic oxygen carriers.
3. Metals in medicines.

Recommended Study Materials (Books):

1) Selected Topics in Inorganic Chemistry. W. U. Malik, G.D. Tuli, R. D. Madan., S. Chand Publications.
2) Inorganic Chemistry (Principles of structure and Reactivity). James Huheey, Eller A. Keiter, Richard L. Keiter. Harper Collins College Publishers.
3) Chemistry of the elements, 2nd edition. N. N. Greenwood and A. Earnshaw. Pergamon.
4) Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5) Magnetochemistry, R.L. Carlin, Springer Verlag.
6) Principles of Inorganic Chemistry. B. R. Puri, L. R. Sharma and K. C. Kalia. Milestone Publishers & Distributors.
7) Advanced Inorganic Chemistry. Satish Kumar Agarwal & Keemti Lal. Pragati Prakashan
8) Advanced Inorganic Chemistry, (A comprehensive text). F.A. Cotton and G. Wilkinson, Interscience Publishers, John Wiley & Sons.
9) Inorganic Chemistry, 5th edition. Shriver and Atkins. W. H. Freeman and Company, New York.
10) Advanced Inorganic Chemistry Vol II. Gurdeep Raj. Goel Publishing House.

Outcomes: Students will be able to

- Learn basic terms regarding electronic spectra of coordination complexes, interpretation of electronic spectra and various important parameters necessary for it, drawing of Orgel andT-S diagrams used for electronic spectra, prediction of possible electronic transitions present in electronic spectra of coordination complexes etc.
- He/she will understand magnetic nature of complexes, measurement of magnetic moment in coordination complexes, prediction of magnetic nature of complexes using spin only formula.
- He/she will learn the terms such as diamagnetic and paramagnetic nature of coordination

complexes, difference between them, anomalous magnetic moments, spin cross over etc.

- He/she will understand the chemistry of carbonyl and nitrosyl molecules, their application as ligand molecules in complex formation, structure and bonding present in various carbonyl and nitrosyls complexes, applications etc.
- He/she will learn chemistry of boranes, carboranes and metal clusters, the concept of 3C-2e bond used to explain structural aspects in boranes and carboranes, polyhedral skeletal electron pair theory and its applications in explaining structures of metal clustes etc.

Course: Organic Chemistry (CH-203) Credits 4 (60 Contact hours)

Objectives :

- Students should learn the mechanism of electophilic and Nucleophilic substitution reactions
- To develops the ability to apply the knowledge of addition and elimination reactions
- To adopt the knowledge of pyricyclic reactions and sigma tropic reaction. To expose the students to various chemical reactions
- To learn about the addition of C-C Multiple Bonds and Carbon-Hetero Multiple Bonds
- To adopt the skill of writing mechanism of some important name reactions

Course contents:

1.Aromatic Substitution Reactions: 10 Hrs.

A. **Aromatic Electrophilic Substitution:** Introduction, the arenium ion mechanism, orientation and reactivity. Energy Profile diagram, steric effect and the ortho/para ratio, ipso attack, introduction of a third group into benzene ring, Electropihilic substitution in polycyclic and heterocyclic ring system.

Some important name reactions: Diazonium coupling, Vilsmeieier-Haack reaction, Bischler Nepieralski reaction, Gatterman-koch reaction.

B. **Aromatic Nucleophilic Substitution**: SN^1, SN^2 SNAr and SRN^1 mechanism. Aromatic nucleophilic substitution via benzyne intermediate. Factor affecting reactivity in aromatic nucleophilic substitution reaction.

Some important name reactions: ChiChibabin reaction, Somlet Houser and Smiles rearrangement.

2. Addition to Carbon-Carbon Multiple Bonds. 10 Hrs.

a) Electrophilic addition to C-C double bond.
b) Mechanism and stereo chemical aspects of addition reaction involving electrophile, nucleophile and free radicals.
c) Regio and chemo selectivity, orientation and reactivity, conjugate addition.
d) Addition to cyclopropane, hydroboration, Micheal reaction, Sharpless asymmetric epoxidation, hydroxylation of alkene-diol formation

3. Addition to Carbon-Heteroatom Multiple Bonds 10 Hrs.

a) Some general and steriochemical aspect of addition to carbonyl compounds
b) Mechanism and stereochemistry of metal hydride reduction.
c) Addition of organo metallic compounds to carbon-heteromultiple bond (organo zinc, organo copper, organo lithium, reagents to carbonyl and unsaturated carbonyl compounds).
d) **Some important name reactions:** Wittig reaction, Knoevenagel, Claisen, Mannich, Perkin and Stobbe condensation.

4. Elimination Reactions 10 Hrs.

a) The E1, E2 and E1cB mechanisms. Orientation in Elimination reactions.
b) Hoffman versus Saytzeff elimination, Pyrolytic syn-elimination.
c) Competition between substitution and elimination reactions.
d) Reactivity: - Effects of substrate structures, attacking base, the leaving group, the nature of medium on elimination reactions. Pyrolytic elimination reactions

5. Pericyclic Reactions: 20 Hrs.

a) Molecular orbital symmetry, Frontier orbital's of ethelene, 1,3-butadiene, 1,3,5-hexatiene and allyl system.
b) Classification of pericyclic reactions
c) Woodward-Hoffmann correlation diagram, FMO and PMO approaches.
d) Electrocyclic reaction: conrotatory and disrotatary motion, 4n, 4n+2 and allyl system.

e) Cycloadditions: Superafacial and antrafacial addition, 4n and 4n+2 system, 2+2 addition of ketenes, 1,3 dipolar cycloaddition and chelotropic reaction.

f) Sigma tropicrearrangements: Superafacial and antrafacial shifts of H, sigma tropic shifts involving carbon moieties, 3,3 and 5,5 sigmatroic rearrangements.

g) Some important pericyclic reactions: Claisen, Cope and aza-cope rearrangements.

Home Assignments:

a) Electrophilic metallation, Hoesch reaction,Arenechromium carbonyl complexes, Von-Richter rearrangement.

b) Birch reduction, hydrogenation of double and triple bond, addition of carbine (methylene), catalytic hydrogenation

c) Amine catalysed condensation reaction, silanes, Reformatsky reaction, Dieckmann condensation.

d) Problems on pyrolytic syn elimination Ei elimination.

e) Problemson sigmatrophic reactions, chelotropic reactions, The Ene reactions, FMO approach and PMO approach.

Recommended study materials (Books):

1 Advanced organic chemistry-Reaction mechanism and structure, Jerry March, John Wiley.

2 Structure and mechanism in organic chemistry, C. K. Ingold, Cornell University Press.

3 Advanced organic chemistry, F. A. Carey and R. J. Sandburg, Plenum.

4 A guide book to mechanism in organic chemistry, Peter Sykes, Longman.

5 Stereochemistry of organic compounds, D. Nasipuri, New Age International.

6 Modern organic reactions, R. O. C. Norman and J. M. Coxon, Blackie Academic and Professional.

7 Organic chemistry, R. T. Morison Boyd, Prentice-Hall.

8 Organic reactions and their mechanism, P. S. Kalsi, New Age International.

9 Modern organic reactions, H. O. House, Benjamin.

10 Pericyclic reactions, S. M. Mukherji, Macmilan, India.

Outcomes: Students will be able to

- Gain the knowledge of addition reaction between a hetero atom and double bonded carbon compounds.
- Learn familiar name Reactions
- Obtained an outline about mechanism of Aromatic Substitution reactions
- Know synthetically the process relevant Organic –Chemical reactions and be able to discuss the mechanism of these reactions.
- Understand the skill of solving problems of pericyclic reactions
- Getthe clear picture of about pyricyclic reactions

Course: Inorganic Spectroscopy (CH-204) Credits 2(30 Contact hours)

Objectives:

- This course aims to introduce the spectroscopic techniques used to characterize the inorganic molecules and materials.
- To understand principles behind these techniques and interaction of radiation with the matter.
- To understand which information about the inorganic molecules can be deduced from the Photoelectronic, X-ray absorption, NQR, ESR, and Mossbauer spectroscopy.
- To interpret the these spectra of the Inorganic molecular systems.

Course contents:

1.Photo electronic and X-ray Absorption Spectroscopy 05 Hrs.

Photo electronic spectroscopy: Basic principles, photoelectric effect, ionization process, koopman's theory, photoelectron spectra of simple molecules, ESCA, chemical information from ESCA.

X-ray Absorption spectroscopy: Basic Ideas on Extended X -ray Absorption Fine Structure (EXAFS) and X-ray Absorption Near-edge Structure (XANES).

2. Nuclear Quadrupole Resonance (NQR): 05 Hrs.

Basic Concepts- Nuclear electric quadrupole moments (eq) electric fields gradients (EFG) at the nucleus, asymmetry parameter between (eq) and (EFG), nuclear quadrupole energy levels, selection rules and transitions quadrupole coupling constants (qcc), influence weak magnetic field, influence of external electric fields; Equipment for observation of NQR, interpretation of NQR data, applications of NQR.

3.Electron spin resonance spectroscopy 10 Hrs.

Introduction, Principles, Basis for resonance, The hydrogen atom, g value, Presentation of the spectrum, ESR of simple systems and of radical anion of aromatic hydrocarbons, mechanism of hyperfine interaction, hyperfine splitting in isotropic systems involving more than one nucleus, Contributions to the hyperfine coupling constant in isotropic systems, Predicting the number of lines in E.S.R. spectra of radicals, line widths, Mc Connell's relation of electron delocalization. Anisotropic Effects: Zero field splitting and Kramer's degeneracy, factors affecting the Magnitude of the g value, Anisotropy in the g value, epr of triplet states, nuclear quadrupole interaction. Applications of ESR in chemical analysis: determining the geometry of transition metal complexes and biological systems.

4. Mössbauer Spectroscopy 10 Hrs.

The Mössbauer effect, Principle, Doppler shift and recoilless fraction, Mössbauer nuclei, spectral line width, chemical isomer shift and quadrupole splitting (i.e. resonance line shifts due to change in electronic environment and quadrupole interactions), magnetic hyperfine interaction, measurement techniques, applications, elucidation of electronic structure of ^{57}Fe, ^{119}Sn and ^{151}Eu complexes using Mössbauer data.

Introduction, Theory, Instrumentation, Experimental setup, NRVS spectra, chemical and biochemical applications, merits and demerits.

Home assignments: Numerical problems, objective questions and some latest research articles.

Recommended study materials (Books):

1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", Mc Graw Hill.
2. P. S. Sindhu, "Elements of Molecular Spectroscopy", New Age International publisher, New Delhi (2010).
3. B. Narayan, "Fundamentals of Spectroscopy", Allied Publishers Limited, New Delhi (1999).
4. J. M. Hill, "Modern Spectroscopy", John Wiley & Sons Ltd, (2004).
5. N. N. Greenwood, J. W. Akitt, W. Errington, T. C. Gibb, and B. P. Straughan, "Spectroscopic Properties of Inorganic and Organometallic Compounds" The Chemical Society, London, 1968.
6. P. R. Bunker, P. Jensen, "Molecular Symmetry and Spectroscopy", Overseas Press India Ltd., New Delhi (2005).
7. R. S. Drago : Physical Methods for Chemists (2nd Edn.)
8. R. Chnag : Basic Principles of Spectroscopy.
9. F. C. Gibb : Principles of Mossbauer Spectroscopy.
10. C.N.R. Rao : Chemical Application of Spectroscopy in Inorganic Chem.
11. G.M. Barrow - Molecular Spectroscopy.
12. M. Chander - Atomic Structure, Chemical bonding including Molecular Spectroscopy.
13. An introduction to Electron Paramagnetic Resonance, M. Bersohn & J.C.Baired, W.A.Benjamin , Inc N.Y. (1966) 2. High resolution ESR Spectroscopy F. Gerson,(John Wiley & sons– 1970)
14. Nuclear Quadrupole Resonance in chemistry, G.K.Semin,T.A.Babushkina & G.G. Yakobson, John Wiley & sons,(N.Y.)-(1975)

Outcomes: Students will be able to

- Understand the basic principle of the photo electronic spectroscopy and interpret the simple spectra.
- Understand the principles of XANES and EXAFS in the deducing electronic structure information of inorganic materials.
- Know the principles behind the NQR, ESR, Mossbauer and NRVS spectroscopies.
- Importance of the Nuclear electric quadrupole in the characterizing organic and inorganic compounds.
- Know how the electric fields gradient in inorganic molecules influences NQR, ESR, and Mossbauer spectra.
- Interpret of XAS, NQR, ESR and Mossbauer spectra.
- Understand the oxidation state, spin state, coordination geometry, bond distances and symmetry using appropriate techniques.

Course: Quantum chemistry & Spectroscopy (CH-205) Credits 2(30 Contact hours)
Objectives:

- The interpretation of Born-Oppenheimer approximation and the expansion of the electronic wave function in a set of pre-defined many-electron basis functions in the form of Slater determinants is one of the primary objectives of this course.
- The electron indistinguishability and antisymmetric requirements of acceptable wave functions will be correlated.
- Overcoming these issues with approximation methods like variational, linear variational and perturbation methods will be discussed with exactly solved systems.
- The molecular orbital theory and valence bond theories with bonding and anti-bonding orbital concepts help to understand the importance of this course in fundamental understanding of chemical bonding.
- The Huckel molecular orbital theory helps to construct a Slater determinant for conjugated organic systems and interpreting the resulting wave function, orbital energies and resonance energies.
- Finally, the inter-link between quantum mechanics and molecular spectroscopy will be highlighted through overlap integrals, selection rules, symmetry adapted linear combination and molecular orbital theory concepts in order to provide deeper insights into many-particle quantum mechanics.

Course contents: **30 Hrs.**

1. Approximate methods, Schrödinger equation, its importance and limitations, Born-Oppenheimer approximation, Anti-symmetric wave functions and Slater determinants (many electron system e.g. He atom), Exclusion and Aufbau principle, Variation method, Linear Variation Principle, Perturbation theory (first order non-degenerate) and their applications to simple systems;
2. VB and MO theory, Huckel MO theory, Bond-order, Charge density matrix, Unification of HMO and VB theory, their applications in spectroscopy and chemical reactivity, electron density forces and their role in chemical bonding. Hybridization and valence MOs of H_2O, NH_3 and CH_4. Application of Huckel Theory to ethylene, butadiene and benzene molecules.
3. Group Theory and Quantum Chemistry: Vanishing of integrals, Selection rules for Vibrational, Electronic, vibration and Raman spectra, Symmetry adapted linear combinations (SALCs), MO treatment of large molecules with symmetry.

Home Assignments: Numericals
Recommended study materials (Books):

1. Atkins' Physical Chemistry 8th Ed., P.W. Atkins and J. De. Paulo, Oxford Univ. Press (2007)
2. Quantum Chemistry 4th Ed., Ira. N. Levine, Prentice-Hall, New Delhi (1995).
3. Introductory Quantum Chemistry A.K. Chandra, Tata McGraw Hill, New Delhi, (1992).
4. Coulson's Valence, R. McWeeny, ELBS, Britain (1979).
5. Chemical Applications of Group Theory 3rd Ed., F.A. Cotton, John Wiley and sons-Asia, New Delhi (1999).
6. Group Theory and its applications to chemistry,K. V. Raman, Tata McGraw-Hill, New Delhi
7. Fundamentals of Molecular Spectroscopy, C. N. Banwell and E.M. McCash, Tata McGraw-Hill, New Delhi, 1994.
8. Physical Chemistry, Donald A. McQuarrie and John D. Simon, Viva Books Pvt.Ltd.,New Delhi.

Outcomes: Students will be able to

- Understanding of the quantum chemical principles in terms of the complexity arises in the mutli-electronic systems.
- The introduction of molecular orbital theory and valence bond theories will help in analyzing chemical bonding concepts in multi-electronic systems.
- The energy and wave function analysis of conjugated systems will provide an opportunity to emphasize the importance of this course.

Course: Laboratory course-1:(OrganicChemistry:LCH-201)Credits 4 (120 Contact hours)
Objectives:

- To learn the techniques of separation of organic mixtures
- To apply the skill in two stage preparation
- To adopt skill of purification and crystallization
- To able to understand the estimation of given organic compound
- To understand micro scale technique.

Course contents:

A)Qualitative analysis (Separation of binary mixture) (Any8)

1) Separation, purification and identification of compounds from binary mixture solid-solid, solid-liquid and liquid-liquid mixtures are to be given for separation. Chemical methods (no ether), ether separation as well as physical methods are used for separation of mixtures.

2) Not more than one gram of each solid and 3 ml of each liquid should be used for preparing mixtures.

Following list of mixtures is given for guidance or any other combination of mixture may be given.

Separation by chemical methods (no ether)

1. Benzoic acid +Acetanilide
2. β-Naphthol +Aniline
3. α-Naphthyl amine +Urea
4. Salicylic acid +p-toluidine

Ether separation

5. Salicyclic acid + Phthalicacid
6. Sulphonilic acid + Cinnamicacid
7. Oxalic acid +p-Nitro aniline
8. Oxalic acid +m-Dithiobenzene

Low boiling liquids

9. Acetone +Nitrobenzene
10. Ethyl acetate +p-Cresol

High boiling liquids

11. O-Cresol +Nitrobenzene
12. m-cresol +p-Dichlorobenzene

3) Purity of recrystallized compounds should be checked byTLC.

4) Quality and quantity of the compounds and purity should be shown to the teacher/examiner.

B. Organic synthesis (Any 8 should be carried out on **micro scale** using 10 mmol of starting material)

1. Synthesis of 4-chloro toluene from p-toluidine (Sandmayerreaction)
2. Synthesis of triphenyl methanol from benzoicacid.
3. Synthesis of Dibenzylacetone from benzaldehyde(Aldol-condensation)
4. Preparation of p-nitro/p-bromo-aniline fromacetanilide.
5. Synthesis of 7-hydroxy coumarin fromresorcinol.
6. Synthesis of 2,4-dihydroxy benzaldehyde fromsalicyladehyde.
7. Synthesis of 2,4-dihydroxy acetophenone fromresorcinol.
8. Preparation of 1,2,4-tri-acetoxy benzene fromhydroquinone
9. Synthesis of p-methoxy acetophenone fromanisole.
10. Fries rearrangement of phenyl acetate to o/p-hydroxyacetophenone.

(Other suitable experiments may be added)

C. Quantitative analysis (anyfour)

1. Determination of iodine and saponification values of an oilsample.
2. Estimation of nitro group byreduction.
3. Estimation of glucose byiodination.
4. Estimation of –COOHgroup.
5. Estimation of $CONH_2$group.
6. Estimation of –COORgroup.
7. Estimation of unsaturation in the given compounds.

Recommended study materials:

1. A. I. Vogel, A Text book of practical organic chemistry, Longman Sc. And Tech, 4th edition
2. Gnanapragasam N. S., Rammurthy G., Organic Chemistry Lab Manual, S. Vishawnath Publisher Pvt. Ltd. Chennai
3. Practical organic chemistry Mamm and Saunders.
4. A handbook of Quantitative and Qualitative Analysis- H.T.Clarke
5. Organic Practicals – Ahluwalia.
6. Organic Synthesis collective Volumes –Blat
7. Systematic Lab. Experiments in Organic Chemistry –Arun Sethi.(New Age)

Outcomes: Students will be able to

- Learn the pilot separation of the binary mixture
- Familiarize the systematic procedure of organic mixture analysis
- The preparation involving nitration, bromination, Sandmayer reaction, and Aldol condensation
- Learn the test involving identification of special elements
- Learn the confirmatory test for various functional groups
- Understand the technique involving drying and crystallization by various methods
- Expertise the various techniques of preparation and analysis of organic substances
- Learn the estimation of various organic compounds.
- Understand micro scale technique.

Course: Laboratory course-2:(AnalyticalChemistry:LCH-202)Credits 4(120Contact hours)
Objectives:

- To understand the error analysis and statistical analysis
- to be able to perform the experiments on chromatography, conductometry, ph metry, colorimetry, polarimetry, potentiometry, flame photometry
- To become expertise in the kinetics experiments
- To perform different qualitative and quantitive analysis

Course contents:

1. **Error analysis and statistical analysis:** (1) (a) Determination of relative error and percentage relative error for the experimental data (b) Calculation of mean derivation and standard derivation for the experimental data (c) Application of't' test for experimental data. (2) (a) Application of rejection criteria ('Q' test) for experimental data. (b) Treatment of analytical data with least square method applied to Beer's law for $KMnO_4$ solutions.
2. **Chromatography:** (3) Separation of cat ions and anions by paper chromatography and determination of their Rf values (4) Determination of ion-exchange capacity of an cat ion exchanger and anion exchanger.
3. **Conductometry:** (5) Determination of the strength of strong acid and weak acid from mixture solution conductometrically. (6) Analysis of aspirin by conductometric method.
4. **pH metry:** (7) Acid-base titration in non-aqueous media by pH-me try (benzoic acid in ethanol/NaOH). (8) Determination pKa of weak acid by pH metry. (9) Determination of degree of dissociation of weak electrolyte and to study the deviation from ideal behavior that occurs with a strong electrolyte.
5. **Colorimetry:** (10) Verification of Beer's law of (a) $KMnO_4$ and Cu^{+2} ammonia complex solution. (11) Determination of empirical formula for the formation of ferric salicylate complex by Job's method. (12) Determination of stability constant for the formation of complex between Fe^{+3} ions and 5-sulphosalicylic acid.
6. **Polarimetry:** (13) Determination of rate constant for inversion of cane sugar by Polarimetry. (14) Study of inversion of cane sugar by enzyme kinetics.
7. **Potentiometry:** (15) Determination of the strength of halides in the given mixture using potentiometry.
8. **Kinetics:** (16) To study the kinetics of iodination of acetone.
9. **Flame photometry:** (17) Estimation of Na^{+}/K^{+} by flame photometry
   (18) Determination of hardness of water by complexometric titration.
   (Any other related experiments may be added)

Recommended study materials (Books):

1. Practical Physical Chemistry: B. Viswanathan and P.S. Raghavan
2. Findley's Practical Physical Chemistry, B.P. Levitt Longman.
3. Practical Physical Chemistry, A.M. James and F.F. Prichanrd Longman.
4. Experimental Physical Chemistry, R.C. Das and B.Behra, Tata McGraw Hill.
5. Experimental Physical Chemistry, V.D. Athanale and Parul Mathur New age International
6. Systematic experimental Physical Chemistry by Dr. T.K. Chandhekar & S.W. Rajbhoj.
7. Advance Practical Physical Chemistry J.B. Yadao Goel Pubs. House.
8. Experimentals in Physical Chemistry by Dr. D.V.Jahagirdhar.
9. Experiments in Physical Chemistry by D.P.Shoemaker.

Outcomes:Students will be able to

- Understand the error analysis and statistical analysis
- Perform the experiments on chromatography, conductometry, ph metry, colorimetry, polarimetry, potentiometry, flame photometry
- Carry out kinetics experiments and qualitative and quantitive analysis
- The various analytical methods for different reactions
- Outline about chromatographic techniques

Course: Seminar (SCH - 201) **Credits 1(15 Contact hours)**

Objectives:

- To enhance the presentation skill and stage courage
- To provide the platform to the students to express them
- To be able to prepare the report component and structure
- To increase knowledge of students in the specific subject

Outcomes: Students will be able to

- The presentation skill and stage courage of the students will be enhances
- This activity will provide the platform to the students to express them
- prepare report component and structure
- The knowledge of students in the specific subject will be enhanced

FACULTY OF SCIENCE AND TECHNOLOGY

Pattern for Question Papers

QUESTION PAPER PATTERN FOR 50 MARKS THEORYPAPER

IMPORTANT NOTES:

1) Attempt any five questions out of seven.
2) All questions carry equal marks i.e. ten markseach.

Q.1: Explain the following (3 + 3 + 4 = 10 marks).

Q.2: Attempt the following questions (3 + 3 + 4 = 10marks).

Q.3: Attempt the following questions (3 + 3 + 4 = 10marks).

Q.4: Attempt the following questions (3 + 3 + 4 = 10marks).

Q.5: Answer the following questions (5 + 5 = 10 marks).

Q.6: Answer the following questions (5 + 5 = 10 marks).

Q.7: Write short notes on the following: (10 marks).

QUESTION PAPER PATTERN FOR 50 MARKS PRACTICALPAPER

Swami Ramanand Teerth Marathwada University, Nanded

SCHOOL OF CHEMICAL SCIENCES

M. Sc. Practical Examination (FROM JUNE-2019)
M. Sc. First Year (Semester-I / II)

Subject:Chemistry **Lab.Course:**

TotalMarks:50 **Time: 08 Hr**

Date:

Q1. 20marks

Q2. 20marks

Q3. Viva-Voce 05marks

Q 4.RecordBook 05marks

Internal Marks

- Home assignment should be completed for each theory course before 15th of the last month in the teachingsemester.
- Mark list of internal tests, Seminars & Home Assignments should be submitted to the Director within eight days after completion of concern examination.
- Answer books of all Internal Examinations should be shown to thestudents.
- Maximum marks for each Internal Theory paper will be 50. Two test each of 20 marks (total 40marks) + 10 mark for Home Assignment = 50 marks for internal assessment of each Theory coursepaper.
- Maximum marks for each Internal Practical paper will be 50. Two questions of 20 marks each + 5 marks for Viva- voce + 5 marks for Record Book = 50 marks for each internal Practicalpaper.
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